Measuring Training Load in Sports

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Measuring Training Load in Sports

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The principle of training can be reduced to a simple "dose-response" relationship. The "response" in this relationship can be measured as a change in performance or the adaptation of a physiological system. The "dose" of training, or physiological stress associated with the training load, is more difficult to measure as there is no absolute "gold standard" which can be used in the field, making it difficult to validate procedures. Attempts have been made to use heart rate as a marker of intensity during training, but the theoretical attractiveness of this method is not supported by the accuracy and the practicality of using this method during training or competition. The session RPE, based on the product of training duration and perceived intensity is more practical and can be used in a variety of sports. However, the score depends on a subjective assessment, and the intersubject comparisons may be inaccurate. The demands of different sports vary and therefore the methods of assessing training need to vary accordingly. The time has come to reach consensus on assessing training accurately in different sports. There is a precedent for this consensus approach with scientists having already done so for the assessment of physical activity, and for defining injuries in rugby, football and cricket. Standardizing these methods has resulted in the quality of research in these areas increasing exponentially.

In preparation for a competitive event an athlete undergoes systematic training which induces adaptations in the muscle, and metabolic, cardiovascular and neurological systems.[1,2] The training adaptations are associated with changes in performance, such as a delayed onset of fatigue or an increase in power output. This principle of training can be reduced to a simple dose-response relationship between the physiological stress associated with the load of exercise training ("dose") and the training adaptations ("response").[1] While the "response" can be measured rather easily, either as a change in performance in the laboratory or field or as a physiological adaptation, the "dose" imposes more difficulty and logistical challenges. This is unfortunate as it impedes the ability to derive accurate cause-and-effect relationships between the training an athlete does and the resultant changes in performance. As a result coaches or trainers prescribing exercise still have to rely to a certain extent on intuition and external training load (ie, distance covered or time of training session), rather than a more preferable internal training load defined by the physiological stress. The fact that there is often disagreement

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between the perceptions of training load of the coaches compared with that of the athletes,[3] confirms the need for a more objective method.

It is not only the coaches or trainers who need to measure training load. Researchers investigating various aspects of training, such as relationships between injury and training load, overtraining, efficacies of various training strategies, to name but a few, also need a valid and reliable method of quantifying training. Numerous reviews have been written on this topic, comparing different methods of assessing training load and attempting to relate the accuracy of different methods.[1,4] All studies are faced with the same obstacle; the "gold standard" is difficult to measure and therefore any attempts to quantify internal training load, or physiological stress, are limited because there is no absolute accurate and objective source of comparison. Despite these difficulties numerous methods to quantify training load have been proposed.

Methods Used To Quantify Training Load: Pros and Cons

Laboratory Measures

Physiological measurements associated with exercise intensity can theoretically be considered as a valid marker of the training load. For example, oxygen consumption represents the metabolic rate which is directly proportional to training intensity.[5] While this might be a useful, accurate measure in the laboratory, the ability to measure oxygen consumption during training and competition is limited, making this method impractical. Blood lactate has also been used as a marker of exercise intensity. This method, however, has not received much support because there are many factors such as carbohydrate ingestion, muscle damage, nature of preceding exercise and status of the intrinsic buffering system which might affect the lactate/training load relationship.[6] Furthermore, the measurement error associated with measuring lactate concentration, collected from earlobe or finger prick blood, exceeds any meaningful change that one might expect from changes in exercise intensity.[6] As with the measurement of oxygen consumption, lactate concentration may be a useful measure in the laboratory but it does not contribute to an accurate assessment of training load during training or competition.

TRIMP

With the development of light weight telemetric heart rate monitors, which can be worn comfortably during training and competition,[7] there was enthusiasm for developing techniques directed at using heart rate as a measure of training load. Consider for example the training impulse (TRIMP) method which uses heart rate measurements during training as a direct marker of training intensity.[8] This method uses the duration of exercise, heart rate during exercise, resting heart and maximum heart rate to calculate a training impulse, or TRIMP. A basic assumption of this method is that heart rate during exercise is a good marker of exercise intensity—this assumption does not always hold as there are many factors, including environmental (temperature and humidity), physiological (ie, state of hydration, diurnal change, state of training) and psychological factors which may affect the heart rate/exercise intensity relationship.[9] Another limitation of this technique is that the equation depends on a weighting factor, the origins of which can be criticized. Although the nuances of the equation have been investigated in various studies, there are still questions about the practicality and accuracy of using the TRIMP as a method to quantify training. As this technique uses a heart rate monitor, one always runs the risk of losing data should the instrument fail, or a heart rate monitor is not available for that particular training session.

TRIMP: Critical Power

An alternate model, which tries to overcome the limitations of the heart rate dependent TRIMP, has been proposed.[10] This model uses individualized critical power/velocity, rather than heart rate to calculate a training impulse. Critical velocity defines the relationship between distance and time to exhaustion at a constant velocity and is calculated as the slope of a regression line between the distance at each velocity and the time to exhaustion. While the theoretical basis of the model is more secure than the theory of the TRIMP based on heart rate, the practicality and usability of this technique still needs to be determined, particularly for physical activity involving intermittent, short duration, high intensity exercise.

Session RPE

In response to the need of being able to quantify training, and considering the limitations of the existing heart rate dependent techniques of the time, Carl Foster devised a method intended to circumvent the problems associated with measuring heart rate during training and competition.[11] This method was called the session RPE and is a self-reported rating of the overall difficulty of the exercise bout, obtained 30 min after the completion of the exercise. Session RPE is calculated by multiplying the relative perceived exertion (RPE) of the session (scale of 0 to 10) by the duration of the exercise (in minutes), or the number of repetitions for resistance training.[12–14] An attractive feature of the session RPE is that the perception of effort is a reflection of the combination of the physiological stress at that time, whether that be as a consequence of resistance training, high-intensity interval training or plyometric training.[15] Studies have shown that the session RPE is a valid and reliable measure of training load during constant load exercise.[16] Other studies have shown that the correlations between the session RPE after soccer training and Banister's TRIMP averaged $r = .60$ after soccer,[17] $r = .76$ after running,[18] and $r = .74$ after swimming training.[3] The use of the session RPE with resistance training has also been evaluated with studies showing that RPE is influenced more by resistance load than by volume. Therefore, performing more repetitions with a lighter load is perceived as being easier than performing fewer repetitions against a heavier load.[12] Furthermore, the RPE varies depending on the muscle groups recruited, the range of motion and the number of joints involved in a movement.[12,13] The fiber type of the recruited muscle, the order in which the exercises are performed, the experience of the athlete in resistance training and the time after the session at which RPE is reported may also affect RPE.[12,19] The latter can be overcome if the RPE score is given at a controlled time after the training session, as prescribed in the original paper.[11] Therefore, although the session RPE is a useful measure of training load it is not without limitations. Also some team sports such as rugby league and rugby union are not suited for this method of assessing training load. In these sports the physical stress following a training session or match will include the stress resulting from collisions which may result in muscle damage[20] as well as the physiological stress arising from intermittent, short duration, high-intensity exercise. Furthermore, in these sports the different playing positions are associated with different demands with some players having much more physical contact than others. These types of sports need a specially adapted method for assessing training load. While the session RPE may cater for how the player feels, the underlying physiological stress arising from the collisions may not be well represented with such a score.

Needs of Specific Sports

In contrast to the sports described above, certain sports such as cycling are suited for a more accurate method of assessing external training load and physiological stress. Mobile ergometers are now available which enable the power output of the cyclist to be measured while they are riding their own bicycle during training and competition.[21] This combined method, with the measurement of heart rate and perception of effort, provides valuable information in terms of physiological stress during a training session. Indeed, the manner in which these three variables change can provide information about whether the cyclist is adapting to training or not.[22]

Global Positioning System

New technology using global positioning system (GPS) offers innovative ways to measure distance covered and speed during training.[23] The accuracy of these techniques has improved considerably so that the margin of error for moderate intensity exercise is minor. However, during sports characterized by short duration, high intensity exercise, the margin of error is much higher.[24] While this technology offers interesting possibilities, the cost of the equipment and imprecision of the measurement at high intensities reduces the practical opportunities, particularly in sports with these characteristics.

The Future

The example from the sport of cycling suggests that it is now time for scientists working is different sports to develop evaluation systems for the sport. This methodology should cater for the specific demands of the sport and should be reached by consensus. This will lead to a situation where researchers use the same method for each sport, but that different sports may have different methods of assessment. This approach will have many advantages; most importantly data from different studies will be comparable if similar methods of assessing training load are used. This strategy of reaching consensus for universal methodologies is not novel. About 10 years ago the World Health Organization supported the standardization of the assessment of physical activity as it was clear that such an approach would allow data to be assessed at the global level rather than locally and in individual studies.[25] Further examples of consensus methodologies can be found in the standardization of the descriptions of an injury in rugby union,[26] football[27] and cricket.[28] These descriptions have been well accepted and it is probably fair to say that it will be very difficult to get any research published if the definitions described in these consensus documents are not used. Furthermore, the quality of the research using these consensus methodologies has increased exponentially. Surely the time has come to adopt the same approach and recruit experts in various sports to decide on evidence-based methods for assessing training loads specific to that sport?

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